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Canadian Science Advisory Secretariat
Science Advisory Report 2006/024

FRAMEWORK ASSESSMENT FOR LOBSTER (*HOMARUS AMERICANUS*) IN LOBSTER FISHING AREA (LFA) 34

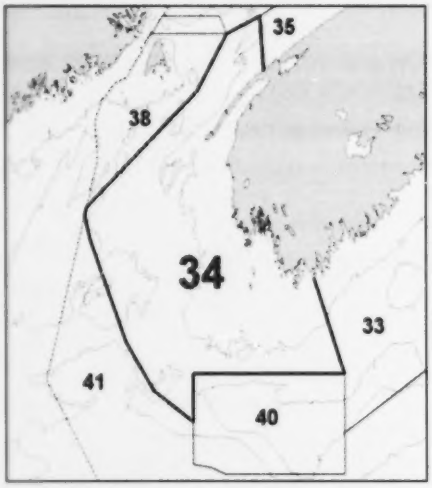

Figure 1: Lobster Fishing Areas (LFA) 34 and adjacent LFAs.

Context

A major conservation management program was initiated in Atlantic Canada in light of the October 1995 review of the Atlantic lobster fishery by the Fisheries Resource Conservation Council (FRCC, 1995). In their report, the FRCC concluded that under the current management regimes, lobster fishermen generally were "taking too much, and leaving too little". Based on the scientific data available to the Council, they concluded that Atlantic lobster fisheries had high exploitation rate and harvested primarily immature animals, resulting in very low levels of eggs-per-recruit (estimated to be as low as one to two percent of what might be expected in an unfished population). While they accepted that lobster stocks have traditionally been quite resilient, they concluded that the risk of recruitment failure is unacceptably high and suggested a need to increase egg production. As part of a four year plan, new data collection and management measures were introduced between 1998 and 2001 with an industry authored Fishery Management Plan introduced in 2001.

The status of the lobster stocks in LFA 34 was last assessed by Pezzack et al. (2001). Among the conclusions were that the fishery was experiencing record landings, that there were high exploitation rates and that as a result of v-notching and a minimum size increase (81 mm CL to 82.5 mm CL) eggs-per-recruit (E/R) had increased by 25-35%. The gains in E/R due to v-notching could not be evaluated because it is a voluntary measure and the actual level of v-notching cannot be accurately determined. Reported levels of v-notching in the logbooks has steadily declined since 2001. The new management measure in the 2001 CHP to return culls (lobster with only one or no claws) is thought to have had a very small effect on egg production, but its exact value cannot be evaluated because cull return rates cannot be tracked.

The fishery presently operates under the 2001-2004 Conservation Harvesting Plan, which needs to be reviewed and updated. The Report of the Lobster Conservation Working Group (DFO 2001) supported the goals of increased eggs-per-recruit, but strongly recommended the development of data-intensive indicators to evaluate the stock and fishery. The Lobster Conservation Working Group and Scotia-Fundy Region's Lobster Conservation Strategy, recommended that within each LFA, indicators be developed that are supported by a broad representation of stakeholders. The purpose of this Science Advisory Report is to evaluate the 2004 stock status of lobster stocks in LFA 34 and recommend an assessment framework, including indicators for monitoring the health of the lobster stock, to guide future assessments.

May 2006

Canada

SUMMARY

- **Abundance indicators** for legal size lobster which include landings, catch rate and scallop survey data are primarily positive.
  - Landings in LFA 34 as a whole continue to be above long-term means but peaked in the 2001-02 season.
  - Landings in sub-areas of LFA 34 ("grid groups") generally followed the pattern of the LFA as a whole. A notable exception was in a traditional nearshore ground (grid group 2A, Lobster Bay) which has declined 20% from the mean of the reference period (1998/1999 to 1999/2000) due to a shift in fishing effort away from this area (see below)
  - Catch rates (CPUE) based on logbooks (throughout LFA 34) and on Fishermen and Scientist Research Society (FSRS) data (grid groups 2A and 2B) were also generally higher relative to the reference period but peaked between 2002-03 and 2003-04 depending on grid group.

- **Fishing pressure** indicators showed either increased pressure or no change.
  - A shift in effort away from traditional nearshore grounds is indicated by a decline in numbers of trap hauls in grid groups 1 and 2A and an increase in number of trap hauls in all other grid groups.
  - The increase in fishing pressure in midshore and offshore portions of LFA 34 raises a conservation concern because these grounds have historically supported larger lobsters.
  - Relative to the reference period, the stock is still fished at high levels with estimates for exploitation in inshore areas (2A and 2B) on the order of 70% and higher.

- **Production indicators** showed either no changes or were positive in relation to the reference period.
  - Pre-recruit abundance in a nearshore portion of LFA 34 (grid groups 2A and 2B) in fall, based on CPUE in FSRS traps, continues to be high but has trended downwards in the last one to two years to be at the level of the reference period.
  - The limited number of indicators for berried females show no change from the reference period.

- An **ecosystem indicator** (mean ocean bottom temperatures) fell by about 2.5ºC from 1999/2000 to 2003/2004 and recovered by 1ºC in 2004/2005.

- **Assessment framework indicators** depend upon LFA 34 logbooks, FSRS traps as well as some new data sources.
  - Existing indicators based on LFA 34 logbooks and FSRS traps should be continued and improved.
  - Fishery-independent indicators of abundance of legal sizes are needed to overcome the uncertainty associated with indicators based on commercial fishing where efficiency and strategy change.
  - Additional indicators of fishing effort (vessel size, navigation, trap design etc.) are required.
  - Fishery-independent indicators are also needed for berried females, pre-recruits and newly settled lobsters.

- The **industry** valued its increased role in the preparation for this RAP and wishes to play an even larger role in the future.

BACKGROUND

Species Biology

Nova Scotia lobsters take seven to eight years to reach the legal size of 82.5 mm carapace length (CL). At that size they weigh 0.45 kg (one pound) and molt once a year. Larger lobsters molt less often, with a 1.4 kg (three pound) lobster molting every two to three years. Off southwestern Nova Scotia most lobsters mature between 95 and 100 mm CL at an average weight of 0.7 kg (1.5 lb.). The mature female mates after molting in midsummer and the following summer produces eggs that attach to the underside of the tail. The eggs are carried for 10-12 months and hatch in July or August. The larvae spend 30-60 days feeding and growing near the surface before settling to the bottom and seeking shelter. For the first few years lobsters remain in or near their shelter to avoid being eaten. As they grow, they spend more time outside the shelter.

Lobsters seasonally migrate to shallower waters in summer and deeper waters in winter. Over most of the lobster's range these movements amount to a few kilometres however in the Gulf of Maine, the offshore regions of the Scotian Shelf and off New England lobsters can undertake long distance migrations of 10s to 100s of kilometers.

Current thinking is that the Gulf of Maine lobster population can be viewed as a stock complex, which means that there are a number of sub-populations linked in various ways by movements of larvae and adults. The number and distribution of these subpopulations remains unknown.

Fishery

Lobster Fishing Area (LFA) 34, off Southwest Nova Scotia (Figure 1) encompasses 21,000 km^2 and has the highest landings of any LFA in Canada, accounting for 40% of Canadian landings and 23% of the world landings of *Homarus* sp. Fishing prior to the early 1980s occurred in traditional nearshore grounds but has since expanded to include the entire LFA from the shallow near-shore areas to deep water areas just inside the 92 km (50 nautical miles) offshore lobster line.

A unique feature of LFA 34 and other Gulf of Maine lobster fisheries is the presence of a deepwater component. The offshore fishery (LFA 41) established in 1972 fishes from the 50 nautical mile line to the upper continental slope. Beginning in the late 1970s a few inshore vessels in LFA 34 began to expand out from the traditional nearshore grounds (<55m depth) and fished German and Browns Bank and the Tusket Basin. By the mid 1980s approximately 100 vessels were fishing this deepwater area referred to as the midshore. This number remained relatively constant into the mid 1990s (Pezzack and Duggan 1995). In recent years there has been an increasing number of new larger vessels capable of fishing further from shore and in almost any weather.

The fishery is undertaken by 937 Category A Vessel Based licenses, 30 Communal Based licences (First Nations). The fishery is managed by input controls including a minimum size carapace length, prohibition on landing egg-bearing female, limited entry, a season between the last Tuesday in November through to May 31, and a trap limit of 375 from November to March and 400 in March to May.

Season:	Last Monday in November- May 31
Minimum Legal Size:	82.5 mm CL
Trap Limit:	375, 1st day of season - March 31 400, April 1 - May 31st
No. Licences:	937 Category A (full time) licenses 30 Commercial Communal licences

The lobster fishery began in the 1880s and after a period of high landings in the 1890s landings declined from over 12,000 t to under 2,000 t in the mid 1930s. Landings remained between 2,000 t and 4,000 t until the early 1980s when landings increased dramatically over the entire east coast of North America. The underlying cause of this increase is not known but the large scale nature of the increase suggests an environmental cause, which improved larval and juvenile survival. In LFA 34 landings rose steadily and exceeded 19,000 t in the 2001-2002 season.

ASSESSMENT

Sources of Information

Data sources are as follows:

1. Historical landings (late 1800s to 1998).
2. Lobster Catch and Settlement Reports (LFA 34 log books). These were begun in fall 1998 and provide daily records of catch, effort and location by 10 minute grids (1998-2005).
3. At-sea samples of the commercial catch (1978-2005).
4. The Fishermen and Scientists Research Society (FSRS) recruitment trap project. Begun in LFA 34 in fall 1999, volunteer fishermen keep daily records of lobster count, size and sex in two standard traps (1999-2005).
5. A survey for scallops which captures lobsters as a bycatch (1982-2005).

Indicators for abundance (legal sizes), fishing pressure and production (pre-recruits and spawners) were developed from the above data sources. Indicators for abundance include landings, catch rate and lobsters caught as a bycatch during the scallop survey. Indicators for fishing pressure are numbers of trap hauls, numbers of grids fished, percentage of catch in the first molt group and exploitation estimators (Change-in-ratio, Length Cohort analysis and a new depletion method). Indicators for production were pre-recruit catch rate from FSRS traps and from at-sea samples of the commercial catch. Indicators for spawners from these same sources proved to be of limited value.

Indicators were categorized as positive ("+"), negative ("--") or neutral ("0") based on a comparison between the last five fishing seasons (2000-01, 2001-02, 2002-03, 2003-04, 2004-05) and a reference period: the two seasons included in the last assessment (1998-99 and 1999-00).

To account for the fact that LFA 34 is a large and diverse fishing area, indicators were applied to specific "grid groups" (Figure 2). These grid groups were based on nearshore, midshore and offshore areas that were further divided into northern and southern components. Additional subdivisions (A and B) of grid groups 2 and 4 were based on known size differences and the history of fishery. For some analyses these subgroups are combined.

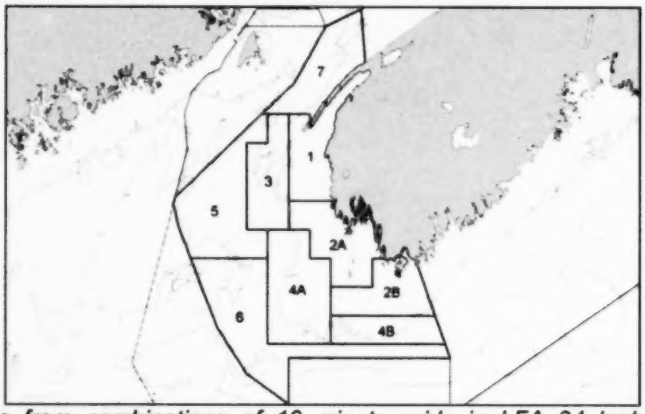

Figure 2: Grid groups from combinations of 10 minute grids in LFA 34 logbooks. Indicators were examined for these grid groups.

In recognition of seasonal differences in fishing characteristics, indicators were also evaluated for within-year fishing periods:

1. Fall – Season start to December 31,
2. Winter – January 1 to March 31 and
3. Spring – April 1 to May 31 (or end of season).

Abundance (Legal Sizes)

Abundance indicators for legal sizes which include landings, catch rate and scallop survey data are primarily positive.

Landings in LFA 34 as a whole continue to be above long-term means but peaked in the 2001-02 season (Figure 3). Landings in sub-areas of LFA 34 ("grid groups") generally followed the pattern of the LFA as a whole. A notable exception was a traditional nearshore ground (grid group 2A, Lobster Bay) which has declined 20% from the mean of the reference period (1998/1999 to 1999/2000) (Figure 4). This decline was associated with lower effort (see Fishing Pressure Indicators).

Landings (mt)

1995/1996 to 1999/2000 average	2000/2001	2001/2002	2002/2003	2003/2004	2004/2005
11,859	16,503	19,284	19,000	18,955	17,007*

* Preliminary

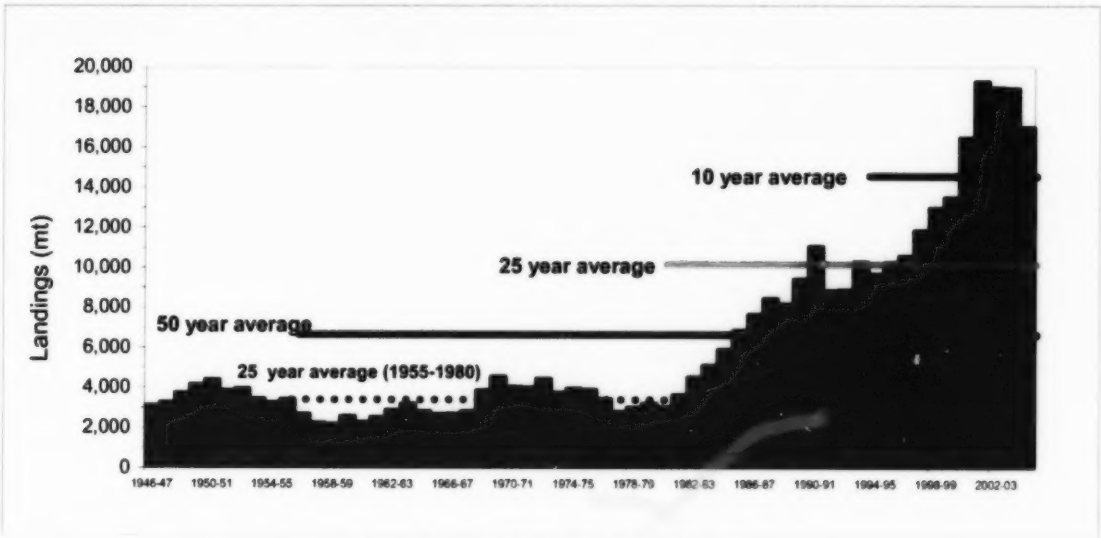

Figure 3: Landings in LFA 34 showing historic means.

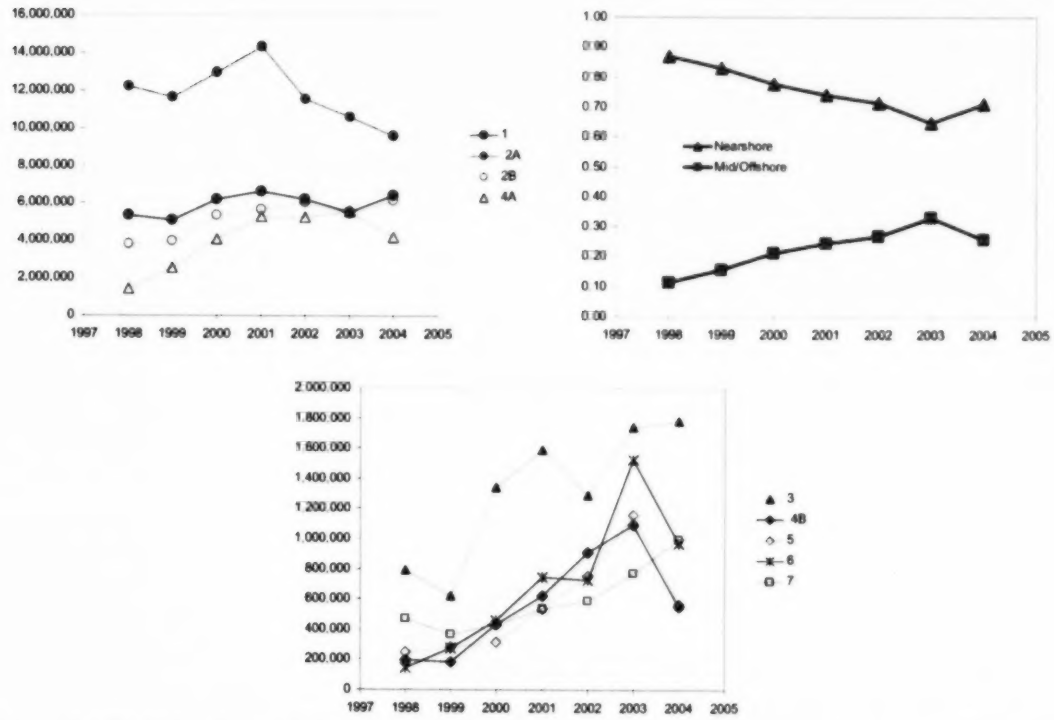

Figure 4: LFA 34 landings by grid groups 1998-1999 to 2004-2005 and proportion of the catch from nearshore (1, 2, 7) and midshore/offshore (3,4,5,6).

Catch rates based on logbooks (throughout LFA 34) and on FSRS data (grid groups 2A and 2B) were also generally higher relative to the reference period but peaked between 2002-03 and 2003-04 depending on grid group.

Catch rate (lb per trap haul) from LFA 34 logbooks was analyzed using a log-linear model. A catch rate index over the last five years showed a pattern similar to the landings: generally higher than 1998-99 and 1999-00 but declining in recent years (Figure 5, Table 1). Fall catch rates in the last five years were higher in all grid groups relative to 1998-99 and 1999-00, winter and spring catch rates showed either no change or higher levels (Table 1). Fall catch rates declined in 2004-05 in most grid groups.

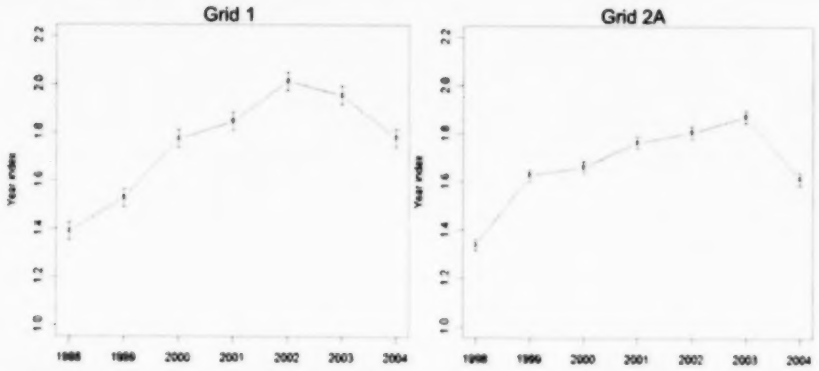

Figure 5: Index and confidence intervals for catch rate ("Year index") for fall for the grid groups with the highest (2A) and second highest (1) landings. The Year index is on a log scale---the index range of 1.35-2.0 is approximately equal to 3.8-7.4 lb per trap haul.

Table 1: Abundance Indicators. Symbols: "+" if three of the last five years are greater than mean of 1998-99, 1999-2000; "--" if less than mean; neutral ("0") otherwise.

	1	2A	2B	3	4A	4B	5	6	7	ALL
Landings Fall	+	--	+	+	+	+	+	+	+	+
Winter	--	--	+	+	+	+	+	+	+	+
Spring	--	+	+	+	+	+	+	+	+	+
All Periods	--	--	+	+	+	+	+	+	+	+
Proportion of landings	--	--	0	+	+	+	+	+	+	
Catch rate (logs, raw) Fall	+	+	+	+	+	+	+	+	+	
Winter	+	+	+	--	+	+	+	+	+	
Spring	0	0	+	--	+	+	0	0	+	
Catch rate (logs, model) Fall	+	+	+	+	+	+	+	+	+	
Winter	0	0	+	0	+	+	0	0	+	
Spring	0	0	+	0	0	+	0	0	0	
Catch rate (FSRS, model) Fall		+								
Winter										
Spring		+								
Scallop Survey – Lobster bycatch	--	+			+					

A catch rate index for legal lobsters in FSRS recruitment traps for an inshore portion of LFA 34 (grid groups 2A and 2B combined) trended similar to the logbook catch rate index (Table 1). Both fall and spring catch rate indices for FSRS traps were higher in the last five years relative to 1999-00, and declined in 2004-05.

The catch rate of legal-sized lobsters in a scallop survey was lower relative to 1999-00 in grid group 1, and higher in grid groups 2A and 4A (Table 1).

Fishing Pressure

Fishing pressure indicators showed increased pressure or no change in LFA 34. Overall trap hauls in three of the last five years were higher than the mean of 1998-99 and 1999-00 but the differences are not large.

A shift in effort away from traditional nearshore grounds is indicated by a decline in number of trap hauls in grid groups 1 and 2A and an increase in number of trap hauls in all other grid groups. More effort is still deployed on traditional nearshore grounds, but over the last five years there was a shift in effort to midshore and offshore portions of LFA 34 relative to 1998-99 and 1999-00 (Table 2). Overall mobility of the fleet appears to have increased based on the numbers of grids fished, but number of days fished was lower relative to 1998-99 and 1999-00.

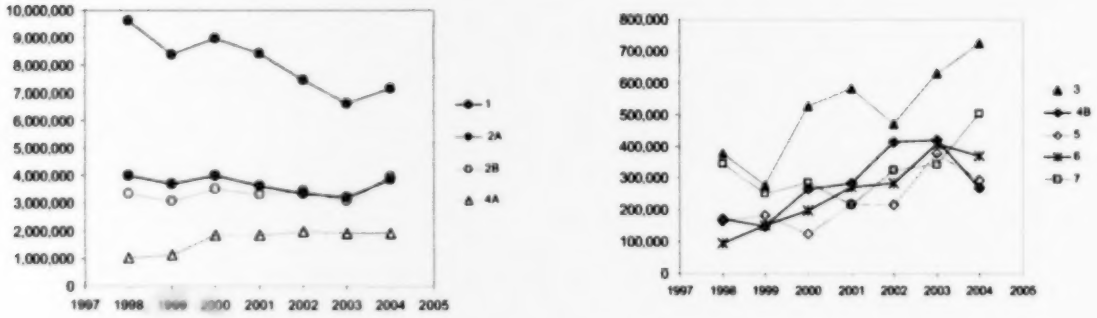

Figure 6. Fishing effort (number of trap hauls) in different grid groups from 1997-1998 to 2004-2005.

The increase in fishing pressure in midshore and offshore portions of LFA 34 raises a conservation concern because these grounds have historically supported larger lobsters that may be an important source of brood stock (Figure 7). The offshore portion of LFA 34 still maintains a much higher percentage of large lobsters (those in molt group three are 109-125 mm CL) than the nearshore, but the midshore percentage of large lobsters is now approaching that of the nearshore (Figure 7).

Relative to the reference period, the stock is still fished at high levels with estimates for exploitation in inshore areas (2A and 2B) on the order of 70% and higher.

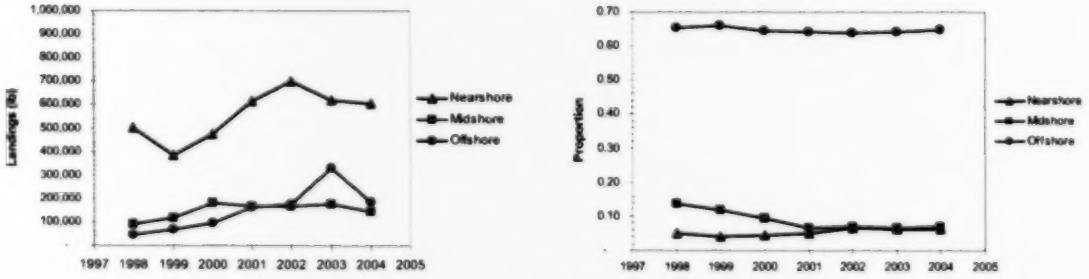

Figure 7: Landings and proportion of the catch in molt groups three plus (greater than 110 mm CL)

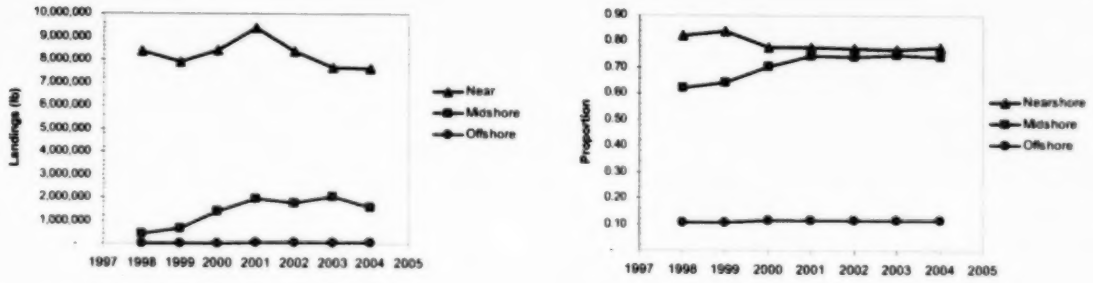

Figure 8: Landings and proportion of the catch in molt groups 1 (82.5 mm to 95 mm CL).

The percentage of lobsters in the first molt group is a coarse indicator of removal rate in that if the percentage is high, it indicates that most of the catch comes from those sizes that have just become available to the fishery (Figure 8). Using the percentage in the first molt group as an indicator of year to year changes is problematic because this assumes that recruitment is not changing over years, and that there is no change in catchability or targeting of specific size groups. These assumptions do not hold up or are in question. Thus, this indicator is only used as an indicator of the average level of exploitation over a number of years, rather than to assess year to year changes. Based on landings and at-sea sample size frequency data, the percentage of lobsters in the first molt group in LFA 34 as a whole has ranged from 79-80% over the last five years, indicating LFA 34 still relies heavily on new recruits and would be immediately susceptible to any changes in recruitment levels.

Length cohort analysis (LCA) uses the same data and has the same assumptions as the percentage in the first molt group indicator. As such it is again used to assess the average level of exploitation rather than year to year changes. For LFA 34, exploitation rate averaged 0.68 over the last five years, the same as the estimate for 1998-99 and 1999-00. For grid group 2A, exploitation estimates from LCA averaged 0.75.

Another method used to obtain exploitation rate estimates was change-in-ratio (CIR) (Claytor and Allard 2003). This method uses the change-in-ratio between a reference or unexploited class and an exploited class over the fishing season to estimate exploitation rate. CIR was applied to the FSRS data. The assumptions of the analysis are that (1) the population is closed, (2) that the ratio of catchability between the classes is constant throughout the season for all traps, (3) that the ratio of catchability by the monitoring traps and by the commercial traps is constant over the season for all classes and (4) that the ratio of the fleet effort to the monitoring trap effort is either constant over the season or can be estimated up to a constant factor.

Two exploitation rates were examined with CIR. The first, called the strict exploitation rate, is defined as the percentage or proportion of the exploitable population caught during a fishing season. However, regulations that increase the minimum legal size (MLS) can result in a smaller exploitable population and therefore increase the exploitation rate, even if catch is constant. As a consequence, a second exploitation rate was examined, called the extended exploitation rate. The extended exploitation rate is defined as the proportion or percentage of the number in the exploited population plus the number in some non-exploited portion of the population. The extended exploitation rate allows a consistent base population to be compared between years that are independent of regulation changes.

Using CIR, strict exploitation rates were high at 0.7-0.9 depending on size group and sex. Male and female extended exploitation rate estimates for the 81-90 mm CL size group are lower than the strict exploitation rate for 1999 – 2000. However, for males the differences are not significant and no change is indicated in the indicator table. Female extended exploitation rates are

significantly lower than strict exploitation rates in three of the five years. This is a beneficial reduction in exploitation rate and is a (+) in the indicator table. Exploitation rate estimates of length-classes 91-100 mm and >100 mm indicate no change in male and female exploitation rates on these sizes as well.

A new exploitation indicator (Gould-Pollock depletion or GPD) was applied to data from grid group 2A only. This is one of a group of so-called depletion methods that assume the population is closed with respect to death, birth, permanent immigration and emigration over the time period that the catch and effort data are collected. While these assumptions cannot be true for any natural population over an entire year, they may hold for short periods of time during the year. Assuming that catches are the only removals from the LFA 34 lobster fishery during the first month or so of the fishery, GPD was applied to the catch and effort data from the FSRS recruitment traps and the DFO fishing log data in grid group 2A (Lobster Bay).

GPD resulted in estimates in the range of 0.6-0.9 depending on the year, data source and modelling approach. Relative to 1998-99 and 1999-00, GPD indicated exploitation rate was lower or unchanged when using logbook data, and higher or unchanged when using FSRS data.

Table 2: Fishing Pressure Indicators. Symbols: Here a negative ("--") indicates an increase in effort because it is considered a detrimental effect, and a positive ("+") indicates a decrease in effort because it is considered a beneficial effect. If three of the last five years are less than the mean of 1998-99, 1999-2000 then a "+" is shown; "--" if greater than the mean; neutral ("0") otherwise. CIR is Change-in-Ratio; GPD is Gould Pollock Depletion.

	1	2A	2B	3	4A	4B	5	6	7	ALL
Fishing effort from logbooks										
Trap hauls – estimated total	+	+	--	--	--	--	--	--	--	--
Trap hauls – % of TOT	0	+	--	--	--	--	--	--	--	--
Mobility – No. of Grid Fished										--
Mobility – No. of Days Fished										+
% of mature females in catch										--
Exploitation rate - CIR										
Extended (81-90, Males)			0							
Strict (MLS-90, Males)			0							
Strict (91-100, Males)			0							
Strict (>100, Males)			0							
Extended (75-90, Females)			+							
Strict (MLS-90, Females)			0							
Strict (91-100, Females)			0							
Strict (>100, Females)			0							
Exploitation rate - GPD										
Exponential - Fishing Logs		0								
Logit - Fishing Logs		+								
Exponential - FSRS data		--								
Logit - FSRS data		0								

Production

Production indicators (indicators of abundance of pre-recruits and spawners) showed no changes or were positive in relation to the reference period.

Compared to indicators for abundance (legal sizes) and fishing pressure, indicators of pre-recruits and spawners are much more limited, i.e. not as many indicators and less data available.

Pre-recruit (61-70 mm CL and 71 mm to minimum legal size) abundance in a nearshore portion of LFA 34 (grid groups 2A and 2B) in fall based on CPUE in FSRS traps continues to be high but has trended downwards in the last one to two years to be at the level of the reference period (Figure 9). Spring catch rates of these pre-recruit size groups showed no trend.

The catch rate of pre-recruits in at-sea samples were variable and showed no trend over the last five years relative to 1998-99 and 1999-00 (Table 3) though pre-recruit catch rates were generally higher than the late 1980s.

The bycatch of sublegal lobsters in the scallop survey relative to 1999 and 2000 was negative for two nearshore grid groups (1 and 2A) and positive for grid group 4A.

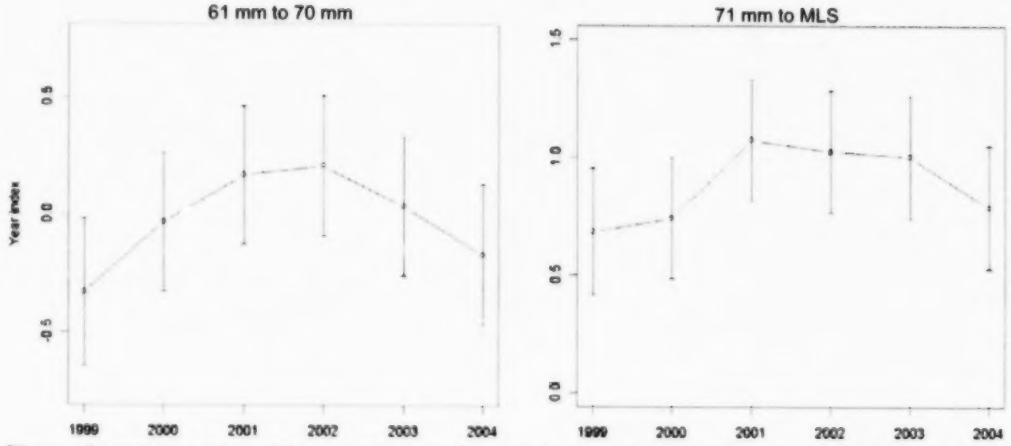

Figure 9: Index and confidence intervals for catch rate of pre-recruits in grid group 2A+B in fall ("Year index")

The limited number of indicators for berried females based on at sea sampling show no change from the reference period.

Table 3: Production Indicators – Pre-recruits and spawners. Symbols: "+" if three of the last five years are greater than mean of 1998-99, 1999-2000; "--" if less than mean; neutral ("0") otherwise.

	1	2A	2B	3	4A	4B	5	6	7	ALL
Catch rate - FSRS traps, model										
Fall <61		0								
61-70		+								
71-MLS		+								
Spring <61		0								
61-70		0								
71-MLS		0								
Scallop survey – Lobster bycatch										
<81	--	--			+					
Catch rate - At sea-samples -										
70-79 mm CL	0	0	0	0	0					
Berried females	0	0	0	0	0					

Ecosystem/Environment

An **ecosystem indicator**, mean ocean bottom temperatures, fell by about 2.5°C from 1999/2000 to 2003/2004 and recovered by 1°C in 2004/2005. Temperature affects lobster growth and the catchability of lobsters in traps, with lower temperatures generally resulting in a lower growth and catchability .

Temperature data collected through the FSRS were averaged into three depth intervals (0-20, 20-40, 40-60 m) for the fall (December 1-Jananuary 15), winter (January 15-February 28) and spring (March 1-May 31) (Figure 10). Mean temperatures decreased for all seasons and depth intervals by about 2.5°C from 1999-2000 to 2003-04, followed by an increase of about 1°C in 2004-05.

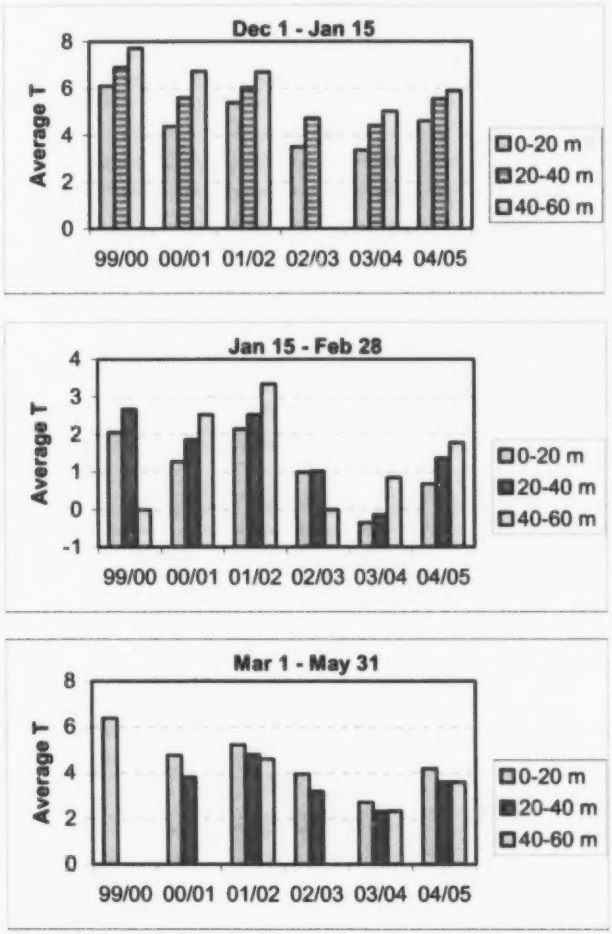

Figure 10: Averaged temperatures in LFA34 of all records in the 0-20 (solid), 20-40 (slanted lines) and 40-60 m (cross-hatching) depth intervals for lobster fishing seasons 1999/2000 to 2004/2005.

Sources of Uncertainty

It is assumed that the subset of commercial fishing logs with useable data is representative of all fishing logs. This is reasonable given that useable records accounted for 85% of all records and catches and 90% of all effort.

Landings are a function of abundance, the level of fishing effort (trap hauls, soak-days, timing of effort and fishing strategy) and catchability. Catchability in turn is affected by environmental conditions, gear efficiency including trap design and bait, and other factors. Changes in any of these can affect landings and catch rates. Thus landings do not necessarily reflect the changes in abundance.

Any changes in fishing efficiency (or "effective effort") have not been accounted for here. If fishing efficiency has increased in the last five years due to larger vessels, better navigation or improved fishing strategy, then the catch rate index may inflate our perception of abundance in recent years. Given that a catch rate index based on FSRS traps showed a trend similar to one based on commercial logbooks, it seems that recent changes in fishing efficiency may not be affecting our perception of abundance.

There are anecdotal indications that larger sizes of lobsters have been targeted in recent years but there is no way of quantifying this shift. An approach is needed to account for changes in fishing strategy and efficiency.

Indicators of pre-recruits do not include midshore and offshore areas of LFA 34 and pre-recruit trends in these areas are unknown

Indicators of mature females assume a size-at-maturity relationship that has not been revisited in a number of years.

ADDITIONAL STAKEHOLDER PERSPECTIVES

The stakeholder members of the LFA 34 Science Committee provided the following perspectives that were not part of the above assessment but aid in understanding the scientific information and advice provided. These include general comments on the process that are not easily incorporated into other sections of the SAR and additional perspectives on the recommended indicators.

General Comments

From an industry perspective, this RAP, through the involvement of industry participants on the LFA 34 Science Committee, is an important step towards developing a partnership between DFO Science and the industry in the process of lobster assessment.

During the five planning meetings over the past year, the industry representatives on the science committee were able to provide their input and perspective on issues related to the key indicators of lobster stock status. These meetings also provided an opportunity for the industry representatives to better understand the methods of science in assessing the stock, the limitations caused by lack of data on some questions, and the need for even greater industry partnering with the science community in the future to further the objective of better understanding of this lobster stock that provides a livelihood for thousands of people in the SW Nova Scotia region.

Fishing Pressure Indicators: The conservation concern of the fishing pressure change from near-shore to mid-shore and offshore relative to the harvest of large lobster requires directed study. The idea that the fleet is fishing harder to maintain landings cannot be investigated by current data collection methods and requires data collection directed at understanding the effects of technology advances and boat design changes on effort.

Research investigating the assumptions of the exploitation rate estimators is required. This investigation is important because it is felt likely that such things as movement of lobster and bait used will invalidate the assumptions and conclusions.

Ecosystem Indicators: Ecosystem indicators including currents during larval drift, food supply, and critical habitat in all areas and water temperature in mid-shore and offshore areas were not considered in the assessment. These are important to consider from the point of view of their effects on abundance.

Recommended Indicators: Early warning (annual) benchmarks for the proposed indicators are required. In view of the socio-economic importance of the commercial lobster fishery to SW Nova Scotia; an assessment every five years may not provide sufficient time for action in the event of a downturn in the stock. These early warning indicators must include ecosystem indicators, particularly temperature, as they influence movement, molting, catchability, and lobster health and quality.

Lobster Health and Quality: Lobster health and quality, particularly in fall and winter, is an important issue to address in this fishery from an ecosystem and economic perspective that was not addressed in the assessment. Ecosystem indicators including food supply and water temperatures are likely to be important factors influencing lobster health and quality. These factors should be examined with respect to the molt stage/ blood protein research indicators currently being collected. The contribution of shifts in fishing pressure to mid-shore and offshore areas to increased observations of soft-shell lobster is also important.

CONCLUSIONS AND ADVICE

Stock Status

Lobsters in LFA 34 as a whole continue to be in high abundance with landings well above long-term means and peaking in the 2001-02 season. Fishing pressure measured by trap hauls continues to be high. Fishing effort is still highest on traditional nearshore grounds but some effort has shifted to the midshore and offshore grounds of LFA 34. This is a conservation concern because the reason for the shift is not clear and there is now additional pressure on lobsters on midshore and offshore grounds which have historically supported larger sizes and potentially important brood stock. This movement of effort from the nearshore should be monitored and its potential effect evaluated.

The LFA 34 lobster fishery continues to have high exploitation rates and to be heavily dependent on new recruits making the fishery immediately susceptible to any changes in the level of recruitment. Indicators of pre-recruits from an inshore area of LFA 34 suggest recruitment continues to be high but has trended downwards in the last one to two years to be at the level of the reference period. This indicator should be followed closely.

The cause of the historical stability of landings in LFA 34, the wide spread recruitment pulse in the 1980-90s and the increase in landings in LFA 34 since 1980 are not well understood. The long term impact of changing fishing patterns over the last 20 years, notably the expansion to areas previously unfished by LFA 34 fishermen needs to be monitored carefully.

Assessment Framework

Recommended indicators depend upon LFA 34 logbooks, FSRS traps as well as some new data sources.

Data Sources: Existing indicators based on LFA 34 logbooks and FSRS traps should be continued and improved. Current fishing logs are essential and provide the basis for current indicators of abundance and fishing pressure. High participation rates, accurate records and timely data entry are required. The FSRS traps provide the only current pre-recruit indicator and should be maintained and expanded where possible. At sea samples should be maintained and focused on specific times and areas where other data sources are lacking. Use of fishermen based measurements from commercial traps should be explored. Data from scallop, groundfish and ITQ surveys should be developed. New fishery-independent surveys should be considered.

Abundance Indicators: Landings are the first level of abundance indicator and although they may not always track abundance changes, landings will continue to be monitored for a variety of reasons. The log-linear model of catch rate from logbooks is a good method to track commercial catch rate and should be updated on an annual basis. To better interpret catch rate changes, indicators of fishing efficiency are needed that would capture improvements in boats, navigation, traps, etc.

Fishery-independent indicators of abundance are needed to overcome the uncertainty associated with indicators based on commercial fishing where efficiency and strategy change. Fishery-independent indicators of abundance could be developed from existing surveys that catch lobsters in towed gear, from standardized trap surveys and possibly from underwater video surveys.

Fishing Pressure Indicators: Percentage of the catch in molt group one and Length Cohort Analysis appear to be limited to evaluating average exploitation over a number of years but can be applied in all areas. Change-in-Ratio (CIR) can be used to compare years and is very useful for certain size groups. This method should be evaluated for midshore and offshore areas of LFA 34, though the size structure in these areas may present a challenge for CIR. The Gould-Pollock Depletion method should be explored further using data from adjacent areas.

Additional indicators of fishing effort (vessel size, navigation, trap design fishing strategy etc.) are required because the LFA 34 lobster fishery is largely effort-controlled and the "quality" of effort is not being tracked effectively. The effect of soak time on our perception of effort should be evaluated. The distribution of fishing effort is extremely important and spatial distribution indicators of fishing effort should be developed from the location data provided in fishing logs.

Production Indicators: The log-linear model of catch rate of pre-recruits in FSRS traps appears to have some reliability down to about 60 mm CL. This indicator should be continued and tracked closely. Indicators of pre-recruits are needed for midshore and offshore areas of LFA 34 since these areas are less amenable to the FSRS type trapping protocol. One possibility is to collect recruitment type data from commercial traps.

Fishery-independent indicators are also needed for berried females and pre-recruits, including newly settled lobsters. Indicators for berried females are needed to estimate reproductive output directly and to track this important component of the population. Recording berried females during commercial fishing in some areas may form the basis for one indicator. Catch rates of berried females in at sea samples are low but the overall size frequency of females could provide a proxy estimate. Some form of sampling outside of the season may be needed to get

an indicator of berried females. Indicators are needed for juveniles that are more than three years away from reaching fishable sizes (< approx 50 mm CL). Such indicators would give advance warning of downturns in recruitment and could be obtained by out-of-season sampling. An indicator for newly-settled lobsters could be developed with specialized sampling.

Ecosystem Indicators: Long-term temperature monitoring throughout the season is essential to understand potential changes in catchability and molt timing. However it will be sometime before indicators such as ocean productivity, predators and prey will be operational.

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